Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 48 (2015) 414 – 426

Procedia Computer Science

International Conference on Intelligent Computing, Communication & Convergence

(ICCC-2015)

Conference Organized by Interscience Institute of Management and Technology,

Bhubaneswar, Odisha, India

Multipath QoS Routing for Traffic Splitting in MANETs

Ch. Niranjan Kumar[a] , N.Satyanarayana[b]

[a]*Dept. of CSE, Sumathi Reddy Institute of Technology for women, Warangal - 506371, India*
[b]*Professor, Dept. of CSE, Nagole Institute of Technology and Science, Rangareddi - 500070, India*

Abstract

Mobile ad hoc networks (MANETs) are characterized by its dynamic topology which has limited channel bandwidth and limited power at the nodes. Because of these characteristics in the MANETs the paths connecting source nodes with destinations may be very unstable and go down at any time, making communication over mobile ad hoc networks difficult. To overcome these issues, in this paper, we propose a Multipath QoS Routing protocol for traffic splitting in MANET. In this protocol, initially multiple disjoint paths are discovered and the data packets are transmitted through the path which satisfies the routing constraints based on bandwidth, delay and path stability. If the path does not satisfy the routing constraints, then the traffic can be distributed along the multiple disjoint paths, using the Traffic Splitting algorithm. By simulation results, we show that the proposed protocol reduces the packet drop and delay with improved throughput.

Peer-review under responsibility of scientific committee of International Conference on Computer, Communication and Convergence (ICCC 2015)

Keywords: Mobile Ad Hoc Networks (MANET); Quality of Service (QoS); Traffic splitting.

Peer-review under responsibility of scientific committee of International Conference on Computer, Communication and Convergence (ICCC 2015)
doi:10.1016/j.procs.2015.04.115

1. Introduction

1.1 MANET

MANETs (Mobile Ad Hoc Networks) is a group of wireless nodes which are capable of developing a network without using existing network since they are infrastructure less. Hence these MANET have become increasingly popular in the computing production. In MANET when the node needs to exchange packets with other nodes, node communicates with other nodes by multi -hop. Communication in such a decentralized network typically involves temporary multi-hop relays, with the nodes using each other as the relay routers without any fixed infrastructure. In MANET each node is free to move randomly. In MANET each node is considered to be equal to other nodes. Each node is capable of transferring the data between the arbitrary source and destination. Thus, each node in MANET can act as a source or destination or router.

The main advantage of these MANETS is due to instant formation of infrastructure less network, they support various services. Also with the usage of MANETs in emergency situations like natural disasters, military conflicts, medical facilities etc, even it is widely used in the multimedia communications. But the issue of the MANETs is it is difficult for maintaining real -time media traffics such as audio and video in existence of dynamic network topology due to high rate requirements and severe delay constraints. [1][2][3][4]

1.2 Load Balanced Routing

The load balancing is a technique in which the existing multi-paths will forward the packets from mobile nodes which have enough capacity remaining. Hence the potential local network congestion can be moderated and it also increases the rate of transmitting with dynamically changing load in the network. Due to load balancing the overall network throughput can be increased and a better QoS can be provided. In the network if all paths have same bandwidth, load-balancing means, the router sends one packet to the destination over the first path, the second packet to the same destination over the second path, and so on. Load balancing guarantees equal load across multiple paths.

Through the load balancing in the network it is possible to distribute workload across multiple paths in order to achieve optimal resource utilization, minimize response time, maximize throughput, increase network life time and avoid overload. Applying the load balancing in the multiple paths it is possible to increase reliability through redundancy. [3][4][5]

1.3 Multi-Path Routing

Routing in the MANETs can be classified according to the nodes and the number of paths available in the network i.e. uni-path routing and multipath routing. Uni-path routing is the routing protocol where only one route is provided to send the data from source node to destination node. In the multipath routing, the protocol provides more than one route to send the data from source node to destination node in the network. Through the multipath routing the load balanced and fault tolerance can be achieved. The multipath routing aims to set up the multi paths between the source nodes and destination nodes. In MANETs there are many multipath routing approach are proposed. For example there is routing algorithm which provides more than one path between the source node and destination node is the Temporally Ordered Routing Algorithm (TORA). The Dynamic Source Routing (DSR) provides an option to the nodes to use an alternate route if the primary path route. [5][6][7]

Types of approaches which support multi path routing [8] [11]

- SMR (Split Multi-path Routing) is routing approach which provides maximum disjoint paths. The routes in the network are discovered on demand i.e. when the sender node sends a request message to the entire nodes in the network. From this request message the destination identifies the multiple disjoint paths and sends a replay message back to the source for each individual path. Therefore this approach estimates the links and the disjoint paths.

- AOMDV (Ad hoc On demand Multi-path Distance Vector routing) is the routing approach which defines a alternative path in each request message and replay message packet between the source node and destination node in the network. In this approach all the paths contain the information about the hop count for each destination i.e. the maximum number of routes is estimated along with the hops difference between the shortest path and an alternative path.

- AODV Multipath (Ad hoc On-demand Distance Vector Multi-path) is the protocol which estimates the multiple node-disjoint paths. In this approach the intermediate nodes forwards the request packet to the destination node. Then the destination therefore replies to all route requests targeting at maximizing the number of estimated multiple paths in the network. Replay packets are forwarded to the source node through the inverse route traversed by the request packets. Therefore this approach establishes only node DISJOINT paths. There is no limitation on the maximum number of paths.

1.4 Advantage of Multipath

In network the communication between the nodes can be beneficial when the multiple paths specifically disjoint paths. In this process the routes are broken and the routing process still alive. Since the node in the network have mobility property and also nodes have poor wireless link quality, the nodes between the source and destination can utilize these routes as backup and primary routes. Also the data packets can be distributed among all discovered multiple paths. Through this way it is possible to increase network lifetime and enhancing load balancing.

Through the multipath routing some of the main advantages can be achieved such as tolerance capability, higher aggregation of available bandwidth and load balancing. Also it is possible to overcome the issues like congestion and bottlenecks in the network. The efficiency of the network will be increased by providing route resiliency. We know that the bandwidth of the nodes is limited in a network also a single path may not provide enough bandwidth for routing process. So the aggregation of the multiple paths it satisfies the bandwidth requirement and a less end-to-end delay may be achieved. [5][7][9][10]

1.5 Issues of Multi Path Routing

Normally in the MANETs the main issue they are facing is in applying the multipath routing techniques. Since the most of the routing protocols distributes the traffic mainly into the primary routes. In this kind of routing the load balanced routing is not achieved. Since only when the primary route breaks the data packets get shifted to alternate routes in the network where the load balance is not achieved. Also if the bandwidth and delay constrained paths cannot be discovered, then the traffic can be distributed along the multiple disjoint paths. Even though there exist some routing protocols which split traffic simultaneously on multiple paths, they have to split up the traffic flow between the source and destination efficiently. So that if one path fails also other paths should send the data packets to the destination.

1.6 Traffic splitting in MANETs

In MANETs the traffic splitting is one of the contexts of multiple path routing which refers to the method of distributing the data packets of a particular node in different paths in the network. The optimal approach in terms of

traffic splitting would be using the shortest disjoint paths. By introducing the traffic splitting in the network it is possible to reduce the video gaps occurrence which is generated by node mobility in the MANETs thus improving the quality of the received video data packets. Through the traffic splitting in the network we can reduce the end to end delay between the source node and destination node and also possible to control the congestion. By using traffic splitting there is an increase in parallel transmission i.e. maximum throughput can be achieved and latency can be reduced. Splitting the traffic to multiple routes in the network can provide a better load balancing, higher aggregate and fault tolerance and also improves network resource utilization and bandwidth optimization. [12][13]

1.7 Previous Work

In our previous study [20], we have proposed to design multipath stable QoS routing for real time traffic in MANET. In this technique, multiple disjoint paths are discovered among source and destination. Among the discovered routes, the optimal paths are selected based on bandwidth constraints, delay constraints and path stability. When any flow request is received, it is initially categorized as real time and non-real time flows where real time flows are given higher priority. For real time flows, bandwidth and delay constrained paths are chosen. For non-real time flows, the stable paths are chosen.

As an extension to this work, we propose to provide load balancing for real time traffic by using Traffic splitting.

2. Literature Review

Soon Y. Oh et al., [14] have proposed multipath routing with/without Network Coding to increase reliability and robustness. The multipath routing strategy employs spatial redundancy in the network by injecting duplicated data so that it increases robustness coping with channel/link errors due to mobility. Network Coding, in addition, injects additional redundant data encoded packets on the multiple paths and thus it can make routing more efficient. The dynamic routing mode switching adapts routing mode to channel conditions. This approach shows a delivery ratio performance close to multiple paths routing, but exhibits a much reduced overhead than multipath in high channel/link error environment.

Carlos T. Calafate et al., [15] have proposed enhancements to the DSR protocol in order to provide a better support to H.264 video stream delivery. The proposed approach focused on the route discovery process, the packet splitting strategy and the preventive route discovery process. The authors have also proposed an alternative metric to PSNR, called video annoyance, in order to measure video gaps in a clear and straightforward manner. The authors have also introduced a dynamic algorithm for maximizing the egree of disjointness of consecutive paths for a same stream, and evidenced the goodness of the algorithm against a more relaxed solution.

Sushil Chandra Dimri et al., [16] have proposed a design for each path a queuing delay based traffic distribution scheme and implemented a k-path routing that allows a given source node to send the data to a given destination node in a MANET. This approach of traffic distribution can increase the reliability of network system, provides the load balancing and minimization of system delay. The simulation results reveal that splitting of traffic approach perform better than the shortest path routing in terms of load balancing, reliability of network and in a minimum mean delay for the whole network.

Gimer Cervera et al., [17] have proposed Multipath routing to increase resilience against network failures or improve security in Mobile Ad-Hoc Networks (MANETs). The Optimized Link State Routing (OLSR) protocol has been adopted by several multipath routing strategies. DM-OLSR approach aims to address a partial view of the network topology, flooding disruption attacks and load balancing in multipath OLSR-based networks. In our function DM-OLSR, nodes select their MPRs with additional coverage during the topology discovery phase and

compute, when possible, t+1 disjoint paths during the route computation phase. The main advantage of this approach it increase resilience against network failures or malicious attacks.

Ji Yong Choi et al., [18] have proposed a load-aware routing metric which is based on Airtime link cost metric and combines traffic loads measured from MAC layer. To maximize load balancing effect, they have utilized their proposed load-aware routing metric into a multipath routing protocol. The advantage of this approach is that the link quality routing metrics are popularly used for route selection but by through this approach the bottleneck and congestion problems can be overcome.

3. Proposed Solution

3.1 Overview

Traffic splitting in the context of multipath routing refers to the technique of distributing the packets of a certain stream through different paths. Splitting the traffic to different routes can provide better load balancing, fault tolerance and higher aggregate bandwidth. Splitting of the traffic can be helpful in reduction of congestion, bottle necks and to minimize the mean system delay, this also improves network resource utilization.

In this paper, traffic splitting is applied in two scenarios:

1. If the bandwidth and delay constrained paths cannot be discovered, then the traffic can be distributed along the multiple disjoint paths.

2. During the transmission, if there is a congestion or overload at an intermediate node, then traffic splitting will be triggered.

The distribution of traffic to different routes is based on the stability and cost of the routes.

3.2 Algorithm for Maximum route Disjointness

if (no path has been chosen previously) then choose the first shortest path;
else {find the shortest node disjoint path;
if (not found) then find the shortest link disjoint path;
if (not found) then find the shortest path with least common links;
if (not found) then choose first shortest path;}

The process of finding the disjointness of one route is always done comparatively to the previously used route. This approach easily adapts to extra routes found through the forwarding or interception of routing packets, as well as to routes which were considered lost. The main goal of this approach is that to find the best choice in each situation, which could be considered computationally expensive for small embedded systems. So we have also proposed an alternative solution

3. 3 Traffic Splitting

A best possible approach in terms of traffic splitting would be one where the shortest disjoint path is used. In general, node disjoint paths are preferable since they accomplish the best trade-off in terms of both bandwidth and resources of node. There are some cases where no node disjoint paths are available and, therefore, link disjoint paths are used. In fact, the link disjointness condition is enough to reduce the effect of mobility on mobile ad-hoc networks. To define a metric that demonstrates the exact gains in terms of traffic splitting using the average degree of path disjointness.

3.3.1 Traffic Splitting on K-Paths

In the network let us assuming a path p (p = 1, 2--k) where the p^{th} path can be modelled as a network. Suppose consider a traffic flow with average passion arrival rate λ exist between source node and destination node, this traffic is then split in k-node disjointed paths, the traffic along path p is T_p. The distribution of traffic T_p is given by

$$\sum T_p = \lambda \quad (1)$$

Now if traffic is distributed among k paths and the distribution of traffic is queuing delay based then of course there is an inverse relation between allocation of traffic and delay for a particular path.

i.e. if T_p is traffic allocated to the path p, where p=1,2,3,…….k,, then

$$T_p \alpha \frac{1}{D_p} \quad \text{and} \quad \sum_{p=1}^{k} T_p$$

Where in the above equation T_p is the traffic allocated on the path p and D_p is the delay of that particular path p. [20]

$$\phi \sum_{p=1}^{k} \frac{1}{D_p} = \lambda \quad (2)$$

In the above equation ǿ is the numerical constant and the λ is the average passion arrival rate.

$$\phi = \frac{\lambda(D_1 D_2 \ldots\ldots D_k)}{D_2 D_3 \ldots D_k + \ldots\ldots + D_1 D_2 \ldots D_{k-1}}$$

$$T_1 = \{\frac{(\lambda \cdot D_2 D_3 .. D_k)}{(D_2 D_3 \ldots D_k + \ldots\ldots + D_1 D_2 \ldots D_{k-1})}\}$$

Finally the traffic allocated T_p on the path p is given by the equation,

$$T_p = \{\frac{(\lambda \cdot D_2 D_3 .. D_{p-1} D_{p+1} .... D_k)}{(D_2 D_3 \ldots D_k + \ldots\ldots + D_1 D_2 \ldots D_{k-1})}\} \quad (3)$$

.....[16]

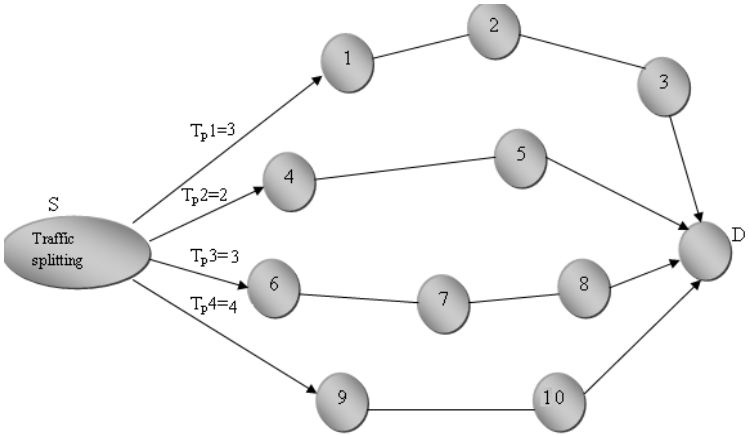

Fig. 1. (a) Path finding in Traffic splitting

In the Fig. 1. (a), the source node transmits the data packet to the destination node. These data packets are transmitted from the source to destination node through the splitting process. In the figure we can observe that the traffic is splitt at the source node. This traffic has been splitt according to the calculated allocated traffic (T_p) for the particular path in the network. Let us assume that the calculated path's traffic allocated be $T_p1=1$ for the path 1, $T_p2=2$ for the path 2, $T_p3=3$ for the path 3 and $T_p4=4$ for the path 4.

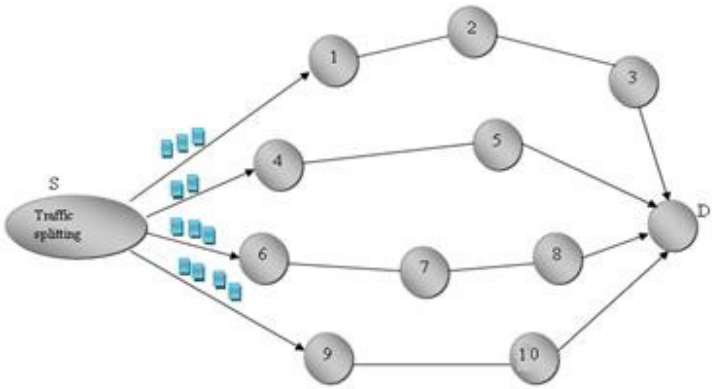

Fig. 1. (b) Data transfer in Traffic Splitting

According to the found traffic allocated values the source node sends the data packets based on that value. In Fig. 1. (b) we can observe that the source node transmitting three data packets on the path1, two data packets on path2, three data packets on the path3 and four data packets on the path4 according to the obtained traffic allocated value. Through this way the data packets have been splitt across the network. By distributing the data packets in the network it is easily possible to transmit the data packets to the destination along with satisfying the constraints.

3.3 Traffic Splitting Algorithm

Step1: Initially to perform the traffic splitting in the network the multiple routes are found.[20]

Step2: During multiple route discovery in the network considers factors like bandwidth, delay and path stability.

Step3: After finding the multiple routes between the source node and destination node, the data packets will be split in order to fulfill the routing requirements in the network.

Step4: This traffic splitting is calculating the traffic allocated i.e. which estimated with the equation (3).

Step5: Through this way traffic splitting of the data packets it is possible to satisfy the routing constraints in the network.

4. Simulation Results

4.1 Simulation Parameters

We evaluate our Multipath QoS Routing protocol for Traffic Splitting (MQRTS) through NS-2 [19]. We use a bounded region of 1000 x 1000 sqm, in which we place nodes using a uniform distribution. The number of nodes is 50. In our simulation, the channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. The simulated traffic is Constant Bit Rate (CBR).

The following table summarizes the simulation parameters used.

No. of Nodes	50.
Area Size	1000 X 1000
Mac	802.11
Simulation Time	50 sec
Traffic Source	CBR
Packet Size	512.
Transmission Rate	250m
Routing Protocol	MQRTS
Rate	250Kb.
Speed	5,10,15,20 and 25m/s

Table 1: Simulation parameters

4.2 Performance Metrics

We compare the performance of our proposed MQRTS protocol with the multipath coded routing (MCR) technique [14] technique. We evaluate mainly the performance according to the following metrics:

Received Bandwidth: It is the number of bits transmitted to the receiver.

Throughput: It is the number of packets received by the receiver during the transmission.

End-to-End-Delay: It is the amount of time taken by the packet to reach the destination.

Drop: It is the number of packets dropped during the data transmission.

4.3 Results & Analysis

Case 1: (CBR)

A. Based on Speed

In our first experiment we analysis the metrics by varying the speed of nodes as 5, 10, 15, 20 and 25m/s.

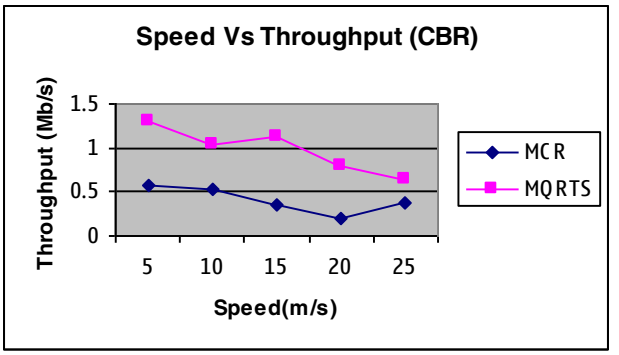

Fig. 2. Speed Vs Throughput

Fig. 2. shows the throughput of MQRTS and MCR techniques for increasing the speed. Since MQRTS selects the path based on bandwidth and distributes the traffic along multiple paths, the throughput is 58% higher than MCR.

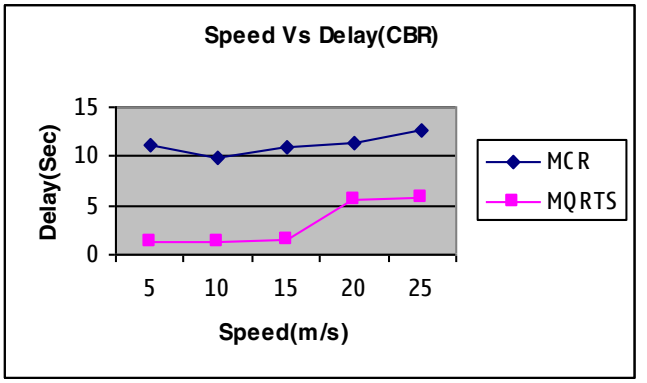

Fig. 3. Speed Vs Delay

Fig. 3. shows the end-to-end delay of MQRTS and MCR techniques for CBR traffic. Since the network coding consumes considerable time, MCR has 73% higher delay when compared to MQRTS. Moreover, delay metric is included in the path selection of MQRTS, it consumes lesser delay along the routes.

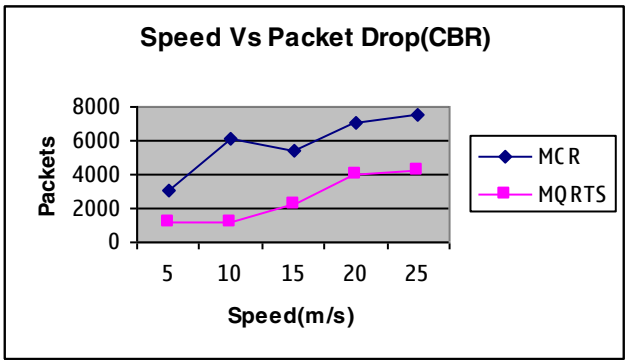

Fig. 4. Speed Vs Drop

Fig. 4. shows the packet drop occurred for both MQRTS and MCR techniques for CBR traffic. The traffic distribution of MQRTS balances the load across the paths and hence minimizing the drop. Because of this, packet drop of MQRTS is 57% lesser than MCR.

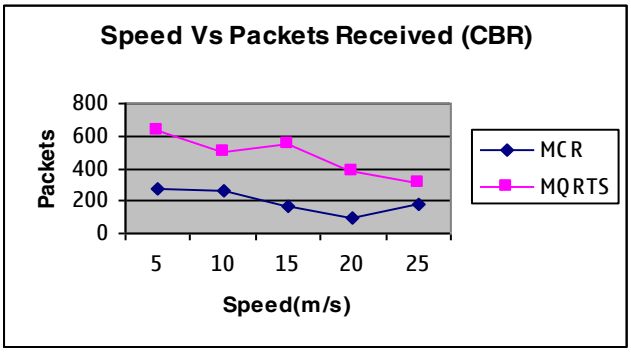

Fig. 5. Speed Vs Packets Received

Fig. 5. shows the packets received of MQRTS and MCR techniques for CBR traffic. We can see that the MQRTS has received 58% more packets when compared to MCR, since MQRTS selects the routes based on bandwidth and stability.

Case 2 : (Video)

A. Based on Speed

In our first experiment we analysis the metrics by varying the speed of nodes as 5, 10, 15, 20 and 25m/s.

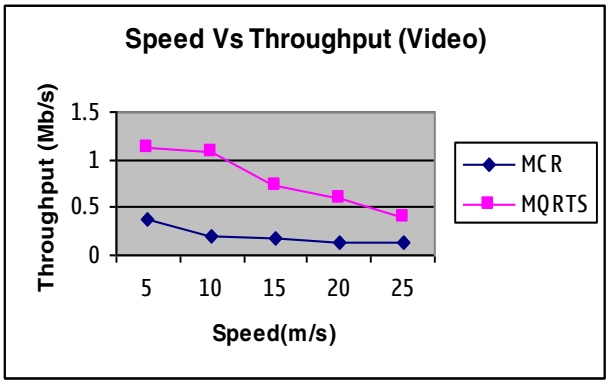

Fig. 6. Speed Vs Received Bandwidth

Fig. 6. shows the throughput of MQRTS and MCR techniques for Video Traffic. Since MQRTS selects the path based on bandwidth and distributes the traffic along multiple paths, the throughput is 73% higher than MCR.

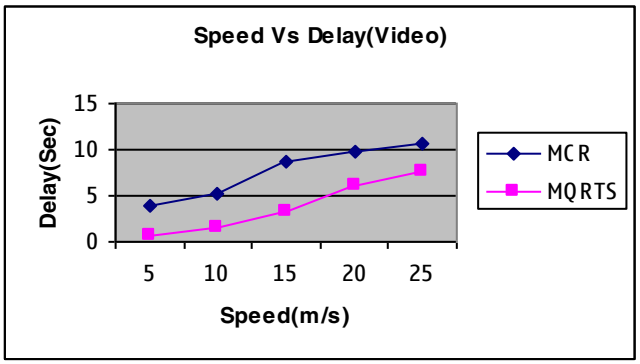

Fig. 7. Speed Vs Delay

Fig. 7. shows the end-to-end delay of MQRTS and MCR techniques for Video traffic. Since the network coding consumes considerable time, MCR has 57% higher delay when compared to MQRTS. Moreover, delay metric is included in the path selection of MQRTS, it consumes lesser delay along the routes.

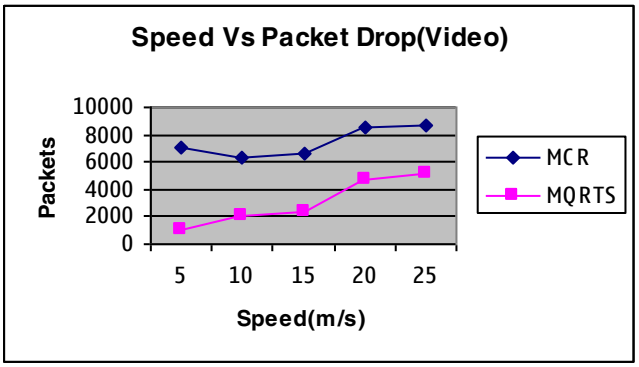

Fig. 8. Speed Vs Drop

Fig. 8. shows the packet drop occurred for both MQRTS and MCR techniques for Video traffic. The traffic distribution of MQRTS balances the load across the paths and hence minimizing the drop. Because of this, packet drop of MQRTS is 60% lesser than MCR.

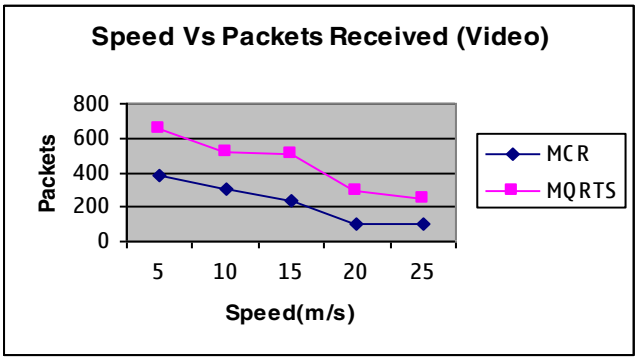

Fig. 9. Speed Vs Throughput

Fig. 9. shows the packets received of MQRTS and MCR techniques for Video traffic. We can see that the MQRTS has received 52% more packets when compared to MCR, since MQRTS selects the routes based on bandwidth and stability.

5. Conclusion

In this paper we have proposed a Multipath QoS Routing protocol for traffic splitting in MANET. In this protocol, initially the network prefers to transmit the data packets through the path which satisfies the routing constraints such as bandwidth, delay and stability of the link in the network. If the path does not satisfy the routing constraints, then the traffic can be distributed along the multiple disjoint paths, using the Traffic Splitting algorithm. By simulation results, we have shown that the proposed protocol reduces the packet drop and delay with improved throughput for real-time and non real-time traffic.

6. References

1. Mohapatra, Prasant, Jian Li, and Chao Gui. "QoS in mobile ad hoc networks." IEEE Wireless Communications 10, no. 3 (2003): 44-53.

2. Huiyao, An, Lu Xicheng, and Peng Wei. "A Cluster-Based Multipath Routing for MANET." Computer School, National University of Defense Technology, Changsha, China (2004): 405-413.

3. Hoang, Vinh Dien, Zhenhai Shao, and Masayuki Fujise. "Efficient Load balancing in MANETs to Improve Network Performance." In ITS Telecommunications Proceedings, 2006 6th International Conference on, pp. 753-756. IEEE, 2006.

4. Ali, Hesham A., Taher T. Hamza, and Shadia Sarhan. "Manet Load Balancing Parallel Routing Protocol." International Journal of Computer Science 9 (2012).

5. S.Venkatasubramanian and N.P.Gopalan, “Multi-path QoS Routing Protocol for Load Balancing in MANET”, International Journal of Networking & Parallel Computing, Volume 1, Issue 3, Dec2012-Jan2013

6. Javan, Nastooh Taheri, and Mehdi Dehghan. "Reducing end-to-end delay in multi-path routing algorithms for mobile ad hoc networks." In Mobile Ad-Hoc and Sensor Networks, pp. 715-724. Springer Berlin Heidelberg, 2007.

7. Pham, Peter P., and Sylvie Perreau. "Increasing the network performance using multi-path routing mechanism with load balance." Ad Hoc Networks 2, no. 4 (2004): 433-459.

8. Parissidis, Georgios, Vincent Lenders, Martin May, and Bernhard Plattner. "Multi-path routing protocols in wireless mobile ad hoc networks: A quantitative comparison." In Next Generation Teletraffic and Wired/Wireless Advanced Networking, pp. 313-326. Springer Berlin Heidelberg, 2006.

9. Mueller, Stephen, Rose P. Tsang, and Dipak Ghosal. "Multipath routing in mobile ad hoc networks: Issues and challenges." In Performance Tools and Applications to Networked Systems, pp. 209-234. Springer Berlin Heidelberg, 2004.

10. Wu, Kui, and Janelle Harms. "Performance study of a multipath routing method for wireless mobile ad hoc networks." In Modeling, Analysis and Simulation of Computer and Telecommunication Systems, 2001. Proceedings. Ninth International Symposium on, pp. 99-107. IEEE, 2001.

11. Koltsidas, Georgios, and Fotini-Niovi Pavlidou. "Single-path and Multipath Routing Algorithms for Mobile Ad Hoc Networks."

12. Calafate, Carlos T., Manuel P. Malumbres, and Pietro Manzoni. "Improving H. 264 real-time streaming in MANETs through adaptive multipath routing techniques." In Global Telecommunications Conference Workshops, 2004. GlobeCom Workshops 2004. IEEE, pp. 433-441. IEEE.

13. Calafate, Carlos T., Manuel P. Malumbres, and Pietro Manzoni. "Mitigating the impact of mobility on H. 264 real-time video streams using multiple paths." Journal of Communications and Networks 6.4 (2004): 387-396.

14. Oh, Soon Y., Mario Gerla, and Abhishek Tiwari. "Robust MANET routing using adaptive path redundancy and coding." In Communication Systems and Networks and Workshops, 2009. COMSNETS 2009. First International, pp. 1-10. IEEE, 2009.

15. Calafate, Carlos T., Manuel P. Malumbres, and Pietro Manzoni. "Route Stability Techniques for Enhanced Video Delivery on Manets." In Mobile and Wireless Communication Networks, pp. 155-166. Springer US, 2005.

16. Chandra Dimri, Sushil, Sushil Kumar Chamoli, and Durgesh Pant. "Delay based Traffic Distribution of Heavy Traffic on K-Paths to achieve the Load Balancing and to minimize the Mean System Delay in MANET." International Journal of Computer Applications 63.22 (2013): 25-30.

17. Cervera, Gimer, Michel Barbeau, Joaquin Garcia-Alfaro, and Evangelos Kranakis. "A multipath routing strategy to prevent flooding disruption attacks in link state routing protocols for MANETs." Journal of Network and Computer Applications (2013).

18. Choi, Ji Yong, and Young-Bae Ko. "Multi-path routing with load-aware metric for tactical ad hoc networks." In Information and Communication Technology Convergence (ICTC), 2010 International Conference on, pp. 370-375. IEEE, 2010.

19. Network Simulator: http://www.isi.edu/nsnam/ns/

20. Ch.Niranjan Kumar and N.Satyanarayana, "Multi-path Stable QoS Routing for Real-time Traffic Applications in MANET", International Journal of Computer Applications (0975 – 8887, Volume 72– No.8, May 2013